Some Basic Concepts of Translators and Identifiers Used in Telephone Switching Systems

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The functions and typical designs of translators as applied to automatic telephone switching systems are first reviewed. The fundamental similarity of some existing translation schemes is noted and a discussion given of the factors which can be juggled to obtain economic application of such schemes.

Identifiers and their uses are next described and some processes of identification are shown to have much in common with those of translation. Complications encountered in commercial application are discussed. Some needed improvements in general designs, possibly by new approaches, are indicated.

Finally, the author points out the frequent occurrence of translation and identification processes in switching elements which are not labeled "translators" or "identifiers" and suggests that future improvements in translation and identification methods may consequently be useful in switching circuit networks in general.

Introduction

Those concerned with the technical details of automatic telephone switching circuits usually regard a switching system as made up of a number of types of blocks or elements named in accordance with their main accomplishment in the train of events in handling a telephone call.

Each of these elements is important as a useful cog in making the system work. Some of them, however, have an added distinction, if not a glamour, because their introduction to the switching world made possible fundamental changes in switching technique or in the service which could be offered to subscribers.

Two such elements are translators and identifiers. They will not be defined or explained until later, but a few words concerning their importance may be in order here.

These elements were not used at all in early types of automatic switching systems. The invention of the translator in 1905, by Mr. E. C. Molina,[1] and the philosophy that accompanied it are now generally credited with having laid the groundwork for the Bell System's adoption of systems of the common control type. In these, the paths necessary to reach a called number are not selected by the calling dial but by equipment which is common to many switching elements. The dial merely furnishes the customer's orders to the common equipment which, through the translation process, can set up a more suitable series of paths than is possible within the limitations of direct dial control.

[1] "Historic Firsts": Translation, p. 445 of Nov. 1948 *Bell Laboratories Record*.

The advent of the process which made the dial an order-passing device rather than a direct-control device, of course changed the entire conception of what could be used in the way of automatic switches, how they were controlled and the number and arrangement of switching paths. But more important than the effect on technical methods in the equipment was the fact that the principle of translation reduced the limitations which subscriber numbering arrangements formerly had on the economy of giving subscribers direct access, by dialing, to large numbers of central offices in complicated networks. First the benefit of this was in facilitating dial service in large metropolitan areas, later in making available suitable methods for dialing of toll calls by subscribers. In other words, the translator was a practical means of pushing back the horizon for automatic telephone service.

Systems based on the use of the translation principle are now found in many countries, and the Bell System's most modern crossbar arrangements depend on it more then ever. It is difficult to conceive of a nationwide automatic toll switching plan for a country as large as the United States without the use of translation.

Identifiers are not so old as translators and have, so far, influenced the general design of switching systems in only a minor way. Their importance lies in the fact that they were key elements in introducing to subscribers, both here and in Europe, a new kind of toll service. With this service, whenever a subscriber dials a toll call, equipment in the central office automatically determines his own number and prints or otherwise makes a record of it along with other details of the call so that eventually he can receive a complete statement of toll calls which have been dialed and the detailed charges for each.

Identifiers were essential in the first offices in which this service was provided in order to determine the number of the calling party, and are necessary in plans now envisioned for giving this service in the large number of old-type offices still in service in the Bell System.

Our newer type offices arranged for this service do not employ devices named "identifiers" as the identification function is spread over numerous elements. Nevertheless, the identification process is there and, named or not, it is found in many other situations.

Translators and identifiers, while used for functions which seem offhand to be quite different, are often similar in so far as the general operation and problems of design are concerned and, in fact, have much in common with numerous circuit elements called by different names. Because of their fundamental importance they have been the subject of much invention, directed toward use in specific conditions, the use of different types of apparatus,

improvements in reliability, increase in speed, and, most important of all, reduction in cost. Operable arrangements to meet all sorts of conditions of use can generally be selected from the present fund of knowledge but the choice in practice is much more limited than in theory. However, translators and identifiers, particularly those used on a large scale, can be varied in many ways to obtain maximum usefulness and to minimize the costs, not only of these devices themselves, but also of other parts of the associated system.

In the following discussion a number of devices of these types will be illustrated to provide a general review of some of the methods available, and the factors encountered in practice in trying to obtain a proper balance between costs and usefulness will be examined.

Translators

What are Translators?

The translators with which we are concerned in this discussion deal only with information in the form of electrically coded numbers. The "languages" carrying this information are the coding systems made up of the numbering bases and signalling methods. Unfortunately, the analogy between the switching system translator and an interpreter of languages, implied by our use of the word "translator," is not very consistent.

The term "translator," as used in this paper, means broadly a switching system element which, in response to an inquiry in the form of an input code, supplies an answer in the form of an output code to the element presenting the input code or to some other element. Each code may represent one or more numbers.

The translator may be a device which serves a number of other circuit elements in common, or it may be associated with a single such element or even built into it and unnamed.

Now in practice we will find that in some applications translators are used so that the input codes and corresponding output codes represent the same numbers in different bases or with different signalling methods, that is, the same information in different languages. Here we have the nearest approach to our implied analogy. However, quite commonly, the switching translator is required to do things which would be decidedly out of order in the case of language translation, such as changing the information instead of the language or changing both at the same time.

Some of the variations in switching translator applications which should be noted at this point are:

(1) In practice, translators are arranged with a multiplicity of input and output possibilities. The inputs may be permanently associated with

corresponding outputs or the association may be changeable through movable jumpers or other means. Thus we have two major types of translators—*fixed* and *changeable.*

(2) In most applications the input and output codes have no natural correspondence but require *arbitrary* translation determined by the designers of the system or those who operate it. Translation is of the *systematic* type where there is a definite relationship between the input and output codes. The relationship may be purely mathematical or may follow from some of the peculiarities of the switching system.

(3) The input and output codes may be of the same numbering base with the same or a different number of places. Often the two codes are of different numbering systems and one or both may consist of mixed base numbers.

As discussed later, many devices we do not call translators do in fact have a translating function, but they have been designed with a different point of view and have accordingly been given different but suitable functional names. However, the vagaries of telephone switching nomenclature have in some cases resulted in giving other names to elements clearly having the same functions as elements earlier or elsewhere called translators. The more important variants will be pointed out as we go along. One of these, the term "code converter," seems more appropriate than the original term.

Examples of Use

It may now be in order to give a few examples of the kinds of uses made of translators in automatic switching systems.

(1) Let us assume we have a common control system in a multi-office city. When a subscriber dials the digits of a local number which we call the "office code", indicating the central office unit in which the called subscriber is located, this number is received by the switching equipment of the originating office as a decimal number with three digits or less. The switching equipment, in extending the call to the central office indicated, may have to set up connections at numerous stages of switches, some in distant offices, which are not indicated by the dialed code. The switching operations which must be performed by the control equipment to reach the desired office are indeed represented by a numerical code, but it may be a number quite different from the dialed number and have no natural relation to it. For this purpose a translator is used to convert the dialed number to the required new code comprising the instructions for the switching operations which must be performed. In British practice a translator used in this way is sometimes called a "route table."

Since the routing of calls corresponding to any particular office code

through the switching equipment may have to be changed from time to time, provision must be made in the translator so that the correspondence between dialed codes and switching codes can be changed economically when necessary by the operating personnel by making changes in the wiring of the translators or by other means. At present this is generally done by re-arranging jumpers.

Here then we have an example of a translator of the *changeable* type with *arbitrary* correspondence between the input and output codes.

This type of translation is used with almost all common control systems in the world. With some of these systems it is required because of the non-decimal nature of the switching arrangement. With other types, having decimal switcbes, it is not required but it is nevertheless used in order to make the trunking arrangements more flexible and efficient.

Translators of this type are not large in some cases because of the small number of translations needed. A complete translator is sometimes permanently associated with each circuit element having need for translation service and the translator may be separately mounted or built into the associated circuit. In other cases one or more translators may be arranged for common use by numerous circuits requiring them.

(2) In some switching systems, for instance the panel type, additional use is made of translation in the switching operations involving the further extension of a call after it has reached the desired central office. The numerical code, usually the thousands, hundreds, tens, and units digits dialed by the calling subscriber would, with some types of offices, directly serve to control the switching operation for the final selections; but in panel-type offices the terminations for the subscriber numbers, while arranged in an orderly manner, are not grouped on a decimal basis and a switching control code corresponding to the actual location of the called number must be determined. Here again a translator is used, but the input codes in this case have a definite relation to the output codes which is invariable; so the translator used is of the *fixed* type with *systematic* correspondence between the codes.

This particular application followed from the first American invention relating to translators and marked an important step in the development of switching arrangements not requiring a direct correspondence between dialed numbers and switching operations. This application is now found in many systems.

When we examine the block diagrams of the switching arrangements for the panel and some other systems with this type of translation we do not find any block for this particular translator, as the systematic correspondence

between the input and output codes permitted the translating arrangement to be made a part of other equipment.

(3) In our latest crossbar system the idea of not using the numerical digits of the called number as the switching control code has been carried still further. There are no terminals numbered as subscribers' telephone numbers. The switches obtain access to the called subscribers by connecting to terminals for "line equipment numbers". The line equipments correspond to subscribers' lines and are associated with subscribers' numbers on an entirely arbitrary basis. The equipment numbers are not four-digit numbers but each is a series of five 1- or 2-digit numbers (a mixed base number) which indicate the locations of the equipments on the frames.

Here again use is made of translation to convert the dialed decimal number to the non-decimal number forming the switching instructions the common equipment must have in order to reach a called subscriber. In this case, however, the simple, fixed, systematic type of translator used with the panel system cannot be employed, as the associations of the input and output codes are entirely arbitrary and may be changed from time to time to make changes in number assignments, and so the type of translator employed is of the changeable type with arbitrary correspondence. This type of translator, especially when used for large offices having 10,000 or more numbers (input codes) is decidedly a large scale affair and too costly for permanent association with each circuit unit making use of it. The translating equipment is, therefore, made common and is sectionalized in groups called *number groups* each handling several hundred numbers and operating independently.

(4) In automatic equipments arranged for handling toll calls dialed by operators or subscribers, translation is an extremely important feature especially where the networks are as large and complicated as those of the Bell System. Our latest crossbar toll switching system has many important features and economic advantages made possible by the ingenious use of translation.

In automatic toll switching practice a numerical code of three to six decimal digits is sent to the switching equipment in the originating toll office to indicate the particular geographical area in which the called number is located. The area may be nearby or far away, trunking may involve only a few paths in series or a number of intermediate offices and many interswitch paths. The switching equipment must determine the necessary course of action from the 3- to 6-digit code which has been received, and this is done through the use of a translator.

In the case of our newest toll crossbar office, the output code of the

translator actually consists of many different numbers in various bases, each indicating some different item of information required in order to complete the call. The information includes switching instructions for interswitch paths and intertoll routes of the preferred combination and also indicates where alternate combinations may be found if the preferred choices are busy or out of order.

Because of the large number of possible codes, translators suitable for this application present special design problems.

Typical Translators

Before undertaking an analysis of the general concepts used in translation, it may be well to review some of the typical translation methods which have been used in the field. In the following descriptions, details not necessary in illustrating the general method are omitted.

Fixed Translators

Figure 1 shows the principles of a fixed, systematic translation scheme employed in early panel and other systems for deriving from decimal numbers the switching instructions for controlling some of the non-decimal selections.

This is one of the solutions for case (2) of the examples of use just mentioned. The selection of a called subscriber's number by the terminating equipment in the called central office unit is governed by the last four decimal digits of the number, but the process required with the panel arrangement is in part non-decimal. The numbers are grouped in banks of 100, which means that, once switching has proceeded this far, the wanted number can be selected in the bank on a decimal basis as indicated directly by the tens and units digits of the number. Other groupings of final and preceding equipment involved are not decimal, so the preceding selections must be made on the basis of non-decimal switching control codes obined by the common control equipment through the translation process.

The switching code wanted in this case consists of three numbers for controlling selections called incoming brush (IB), incoming group (IG) and final brush (FB), and must be derived from the combination of the thousands and hundreds digits of the called subscriber's number as recorded on the register switches by the calling subscriber's dial. This can be done because the non-decimal arrangement of the switching equipment is orderly and there is, therefore, a systematic relationship between the input and output codes.[2]

It will be noted that the input code consists of a ground on one lead in

[2] Oscar Myers, Codes and Translations, *A.I.E.E. Transactions*, Vol. 68, 1949.

each of four groups of leads from the "thousands" and "hundreds" switches. This results in an output code of one marked lead in each of the three groups of non-decimal output code marking leads.

The operation is simple. The IB code is determined directly from the pairing of consecutive terminals on the thousands register. The IG code is

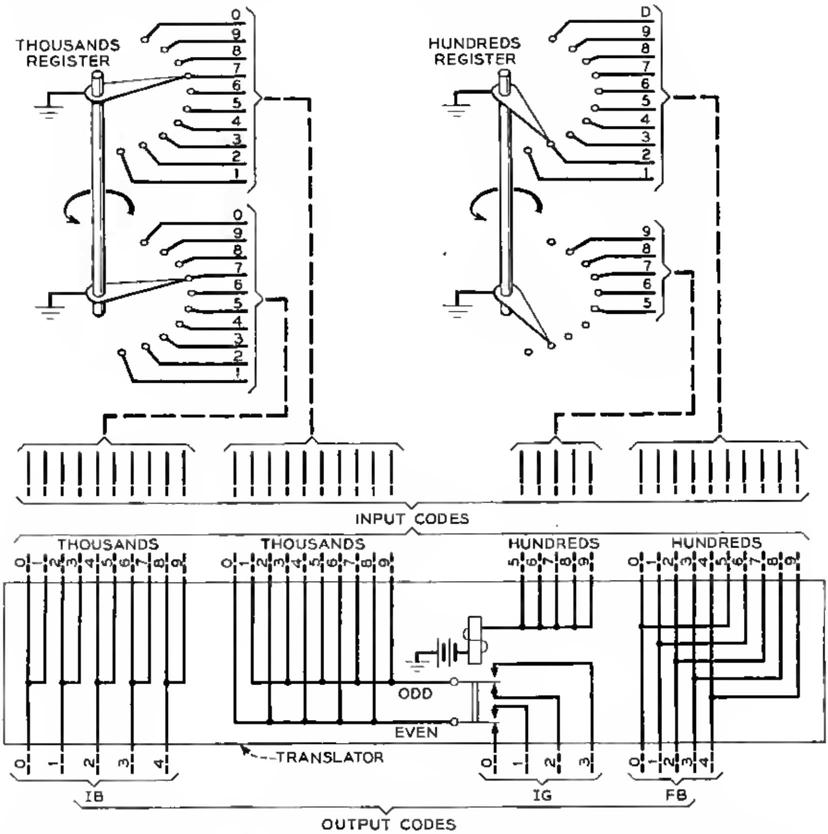

Fig. 1—Fixed, systematic translator used in panel system for converting thousands and hundreds digits of called numbers to 3-part code for control of non-decimal selections. (Changes information)

derived from a combination of the settings of the thousands and hundreds switches, which with the combining relay gives one of four possible code marks depending on whether the thousands number is even or odd and whether the hundreds number is in the first five or last five series. The FB code, one out of five, is derived from the hundreds switch by pairing the numbers in the first five series with those in the last five.

The simplicity of this type of translator makes it economical to furnish one for each switching element (sender) requiring its use rather than providing for use in common. In practice the translator is not even as discrete an element as shown here but is contained in and wired as part of each sender.

It will be obvious that this form of translator may also be constructed with other types of apparatus.

Figure 2 shows another form of fixed, systematic translator used as an element in changing the code for a number in a two-out-of-five system to a one-out-of-ten system. The operation is simply that a mark on two of the five input code leads will cause the operation of the two associated relays

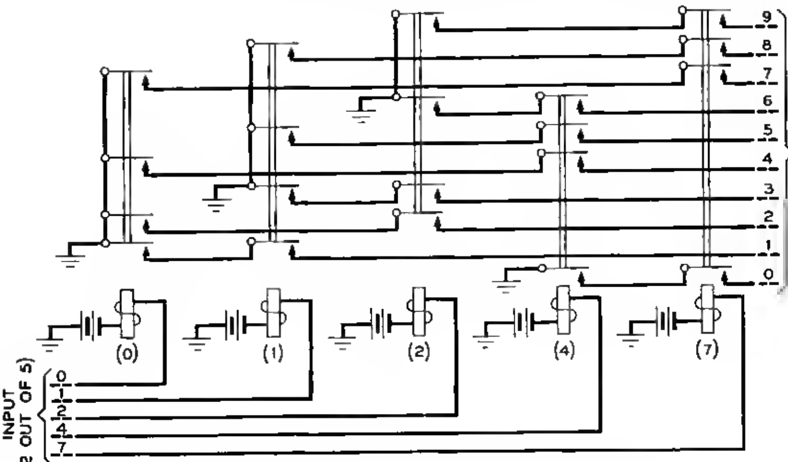

Fig. 2—Fixed, systematic translator for changing the coding for a single-digit decimal number from two out of five to one out of ten. (Changes "language")

which will place a mark on one out of the ten output leads. This element is repeated for each place in the decimal number involved or the same element may be used, by the addition of suitable controls, for translating numerous digits on a sequential basis. Note that the two numbers representing each input code add up to the number being translated, except that seven and four are assumed to add to zero.

Figure 3 shows a systematic translator for changing the code for a number from the decimal to the centesimal system. Here the input code consists of a ground on one lead in each of the two input groups and the output code consists of a ground on one of the hundred output code marking leads. The operation of one of the "tens" relays by the grounded tens lead connects

the units leads to ten output code leads one of which will then be grounded. By adding suitable relays this translator can be expanded to a system in which the output code is a mark on one of a thousand or ten thousand leads.

The arrangement of Fig. 3 occurs frequently as a selection device and when so used in the Bell System is now called a "relay tree".[3] It is often an element of other types of translators.

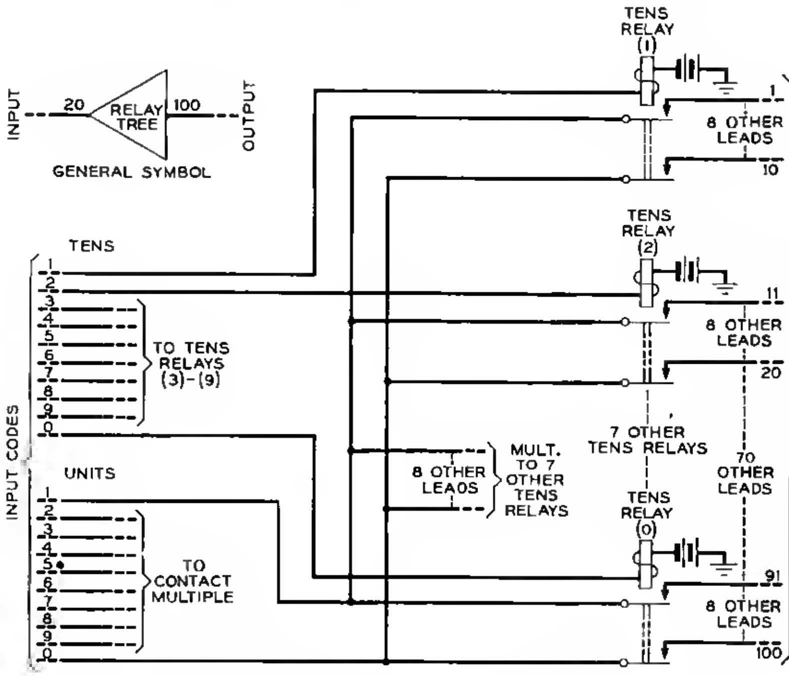

Fig. 3—Fixed, systematic translator for changing a 2-digit decimal number to a centesimal base. (Changes "language")

A 100-point step-by-step switch can, of course, be used as the equivalent of the foregoing type of translator, and is frequently so used. In this case the input code is two sets of decimal pulses to drive the selector to the required point, and the output code is again a mark on one out of one hundred output code marking leads connected to the bank terminals.[4] Such a switch is also used in place of a relay tree as a selecting element in other types of translators.

[3] S. H. Washburn, "Relay Trees" and Symmetric Circuits, *A.I.E.E. Transactions*, Vol. 68, 1949.

[4] This is an elementary sample of a translator with sequential input and combinational output.

Changeable Translators

The Western Electric Company's first full-automatic panel office made use of a rotary-type switch in order to obtain within the senders a trans-

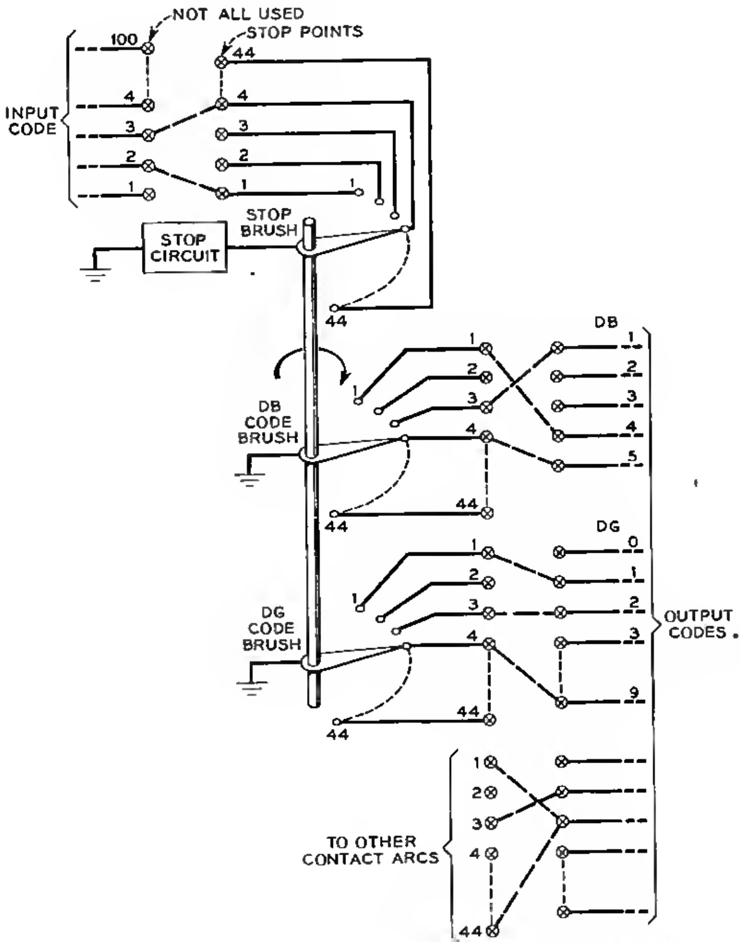

Fig. 4—Changeable office-code translator used in first full-automatic panel office.

lation from the 2-digit office codes to the switching control codes necessary to make the selections to reach the office containing the called number. The fundamental arrangement of this translator is shown in Fig. 4.

In this case the setting of the registers for the first two dialed digits causes a mark to be placed on a terminal in a one-out-of-one hundred

system. This terminal is cross-connected to a "stop-point" or code-point location terminal to which the rotary translator switch is driven. The brushes of the switch make contact with terminals in this position which are arbitrarily cross-connected to various groups of code marking leads for controlling the required selections.

In the first use mentioned above it was economical to provide one of these translators for each sender. In other cases, particularly those involving a larger number of translations, the device was sufficiently expensive to warrant a group of translators for use in common.

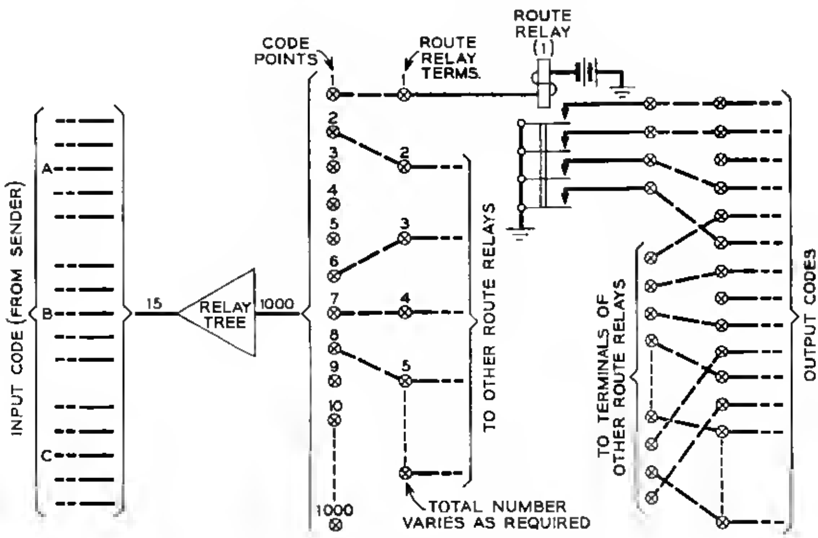

Fig. 5—Relay translator for 3-digit office-code.

It should be noted that this translation arrangement in reality consists of an initial decimal to centesimal translator such as shown in Fig. 3, formed by part of the register switches. This is followed by a cross connection which changes the systematic translation which has already been achieved to an arbitrary translation in the form of a mark on one of the stop points. This is followed by the translation achieved by the rotary switch which converts the one-out-of-one-hundred code to one consisting of marks on numerous code marking leads.

We shall now see how this method is in principle followed by translators used in modern systems.

Figure 5 shows a translator used in a modern crossbar office and, with variations, in other modern offices for translating the dialed office-code to

a switching control code. Note the similarity of the operation to that of the preceding translator.

The 3-digit decimal input code is first translated by the systematic relay tree to a one-out-of-one-thousand code. The marked code point is cross-connected to an arbitrary route relay, the contacts of which are in turn cross-connected as necessary to arbitrary code marking leads to provide tbe required information to the control equipment.

Depending on the economic factors determined by the holding times of the translators and elements served by them and the size of the translator, this type of translator may be individual to such elements or be arranged in common groups.

Preliminary Resumé

Systematic Translators

On the basis of the illustrations given so far, it is possible to make a few observations which will help in the discussion of the more advanced types of translators to follow.

In the first place, it will be evident that the systematic translators used as examples follow no common pattern. Each design bas been carefully tailored to minimize the cost by taking full advantage of the particular relationship between the input and output codes.

This applies not only to the three varieties previously illustrated but also to numerous other forms used in practice. Among these may be mentioned systematic translators having the general functions of the one shown in Fig. 1, but dealing with the different numbering arrangements found in some common control systems outside of the Bell System.

Others are those used for translating code marking lead systems from a hase of 1-out-of-10 to 2-out-of-5, 3-out-of-8 to 1-out-of-40, combinations of 4 to 1-out-of-10 or vice versa, etc. Translations between binary and decimal numeration also occur. These changes in the method of indicating a number within the same switching equipment are, of course, not due to engineers merely changing their minds, but are necessitated by the fact that, no matter what system of numeration and coding may be used within a switching system for the sake of efficiency, telephone numbers and charges for calls must be presented in generally understood terms in so far as the subscribers are concerned.

All of the above fixed translators involve rather simple relationships between the input and output codes. The rules for determining the output codes are in reality instructions for arithmetical treatment of the input code, but the translator does this in a special way without recourse to true computing processes.

There are some cases dealing with the charges for telephone calls where use is made of devices in which the input codes consist of two or more factors, the arithmetical combination of which determines the output code. Small scale electrical or clock-like mechanical computers *are* sometimes used here; but in other cases the devices, because of the limited number of possible outputs, are in reality systematic translators furnishing a limited reference table, although there is a tendency to call them *computers*.

Automatic computers could, of course, theoretically be used in many cases to provide the translation afforded by systematic translators; and it would also be possible to use one of the arbitrary translators mentioned in the foregoing section. We would then be in a position to say that the processes of systematic translation would follow a pattern for various types of applications. However, such arrangements could conceivably be economical only in cases requiring a large variety of fixed translations or in cases where the relationships between input and output codes were very complicated. It seems to the writer most likely that, for the simple types of systematic translation required in switching, special designs, each based on well-known principles of efficient switching network circuitry arranged to fit the special function, will continue to be the most economical.

Arbitrary Changeable Translators

Where there is no uniform relationship between the various possible input and output codes of a translator, and in particular where the output code associated with any given input code is subject to change, we can, in general, resort to one of two things. We can provide a separate translator for each input code, arranged so that it can be modified as the code associations are changed. This is seldom done in practice, and is economical only where there are very few codes and the changes are infrequent. The usual procedure is to provide a translator which can bandle all or a substantial portion of the required codes in a uniform manner without regard in its detailed operation to the arbitrary and changeable relationship between the input and output codes, but providing facilities for the changes required.

The two changeable translators shown in Figs. 4 and 5, not only illustrate methods of doing this with switches and relays, but also illustrate the general principles used in all working translators of this type now in use. The main variations are improvements to reduce costs, either of the translator or elsewhere in the system, or to provide better tractability for changes.

The general principle is that the over-all translation operation consists in causing the input code to select a coding element which is capable of producing the required output code. Changes in the output code associated with the input code are made by wiring or other changes causing different

coding elements to be selected or causing the same coding element to produce different output codes.

For instance, in Fig. 4, the input code, consisting of a mark on one of 44 leads, causes the translator switch to select one of the 44 possible positions and the various terminals contacted in this position and their associated changeable cross connections constitute the coding elements to mark the required output code leads. The output code for any input code can be changed by changing the cross connections in the coding element. In this case they can also be changed by moving the "stop-point" cross connection to a new stop point causing a new coding element to be selected. (This permits numerous inputs to have the same output.)

Now, in the case of Fig. 5, the same general situation exists, each coding element consisting of a route relay with changeable output connections and with provision for changing the relay selected by the input code.

We can now go on to examine some of the variations of this general scheme in practice and theory.

Number Group Translator for #5 Crossbar Office

Figure 6 shows the changeable translator used in the #5 Crossbar System to determine the equipment location number when the called directory number is known. This translator is arranged to handle 1000 directory numbers, but is not limited to this capacity.

The input code is a 3-place decimal number. The output is a mixed base number coded by one mark in each of six groups of code marking leads.

The operation here is preceded by the selection of the correct translator according to the thousands digit of the called number. Then the input code causes the relay tree to select (for three wires) a 3-point directory number terminal each point of which is connected to a coding element furnishing two items of output information.

The economy of this arrangement lies in the use made of resistances for the output coding elements. This is a sample of what has come to be known as passive-element coding, which will be further illustrated later.

The difficulty the designers faced in this case was that each translator, while having only 1000 possible inputs, must provide for translation to a very large number of possible outputs, each different and each consisting of a mark on six different leads. If the scheme of Fig. 4 had been employed, then the translator switch would have required provision for 1000 positions and 6000 wires. If the scheme of Fig. 5 had been used, then a total of 1000 coding relays would have been required and each coding relay would have had six contact sets and cross connections.

By employing a relay selecting tree carrying three wires and using three

separate cross connections for each directory number, each connected to a 2-code passive coding element permanently associated with one marking lead in each of two groups of output code bus bars, it was possible to effect considerable economy over at least schemes like those shown in Figs. 4 and 5.

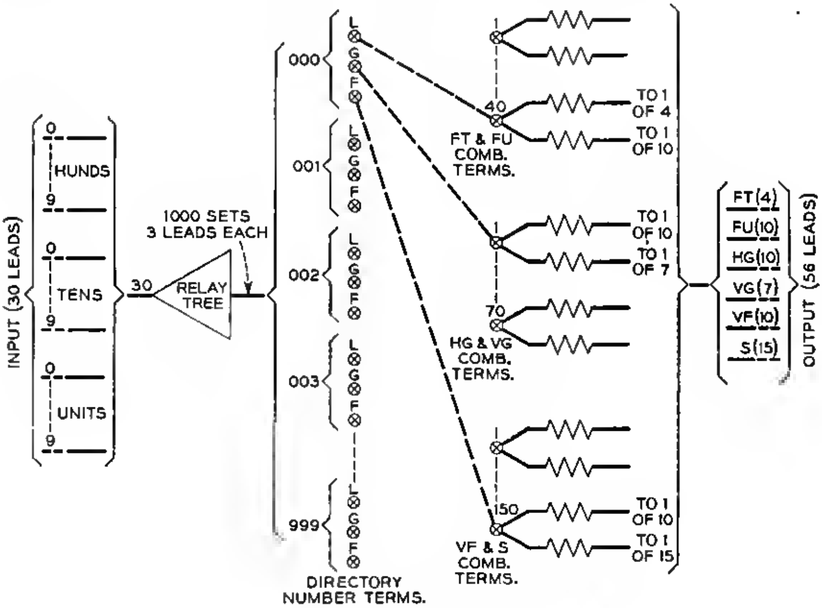

Fig. 6—Number group translator for #5 crossbar office.

Ring Type Translator

An example of a translator with still further simplification and improvement of the coding equipment is that shown in Fig. 7, which is also used in the #5 Crossbar office, in this case for determining the directory number of a calling station when the equipment location number is known and it is desired to make a record of the calling number for charging for the call. This is the reverse translation of the case covered by Fig. 6.

As used in practice, the translator of Fig. 7 is limited to capacity for 1000 mixed base input codes, any of which may be translated to any of 40,000 directory number output codes in a 5-place decimal system.

Here the relay selection tree, under control of the input code, causes the selection of a one-wire circuit to one out of 1000 equipment number terminals each of which has a cross-connection wire which serves directly as the coding element for translating the associated equipment number. This is

due to the fact that each jumper is threaded through a common array of ring-type induction coils with one coil for each digit in each place of the output numbering scheme, that is, 44, as shown in Fig. 7.

After the equipment number selection has been made, a surge of current is passed through the jumper. Since the jumper acts as a single turn primary for all the coils through which it is threaded, a high voltage is induced in

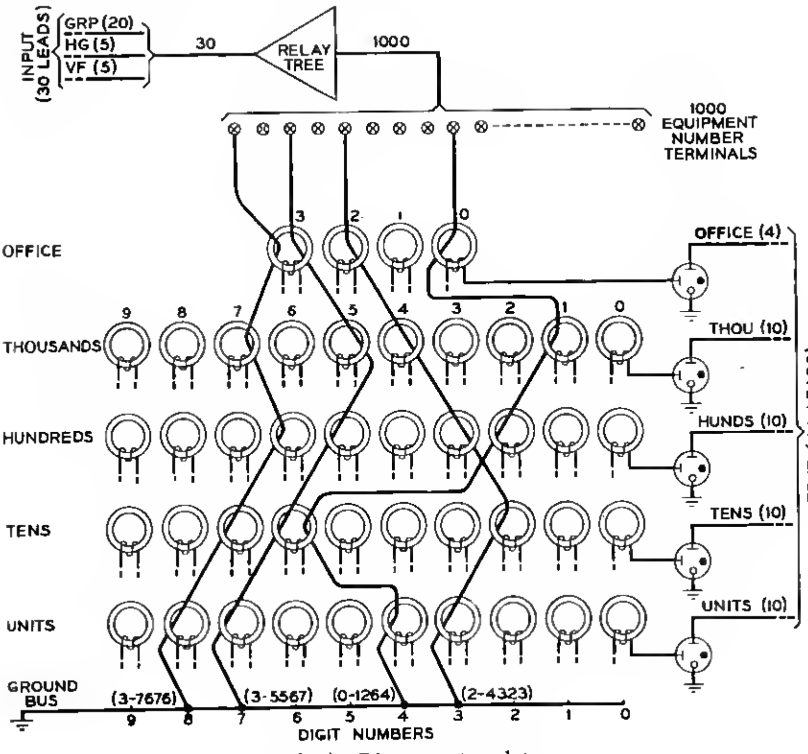

Fig. 7—Ring-type translator.

the high turn secondaries of these coils which causes the cold cathode tube associated with each of these coils to "trigger" and place a mark on the corresponding output code marking lead. The translation for any equipment number is changed by simply threading the associated jumper through different coils.

Many jumpers may be threaded through the same coils. The jumpers thus act as individual coding devices and the coils as a reading equipment common to all coding elements.

The improved coding element arrangements in this translator[5] have eliminated the output bus-bar multiple entirely (existing in Fig. 6 for instance) as each output code lead terminates in the translator only on the cathode of the reading tube. This improves the safety of the device and helps reduce the cost. But the main benefit is in the improved tractability for changes as they involve only one jumper per input code as compared to three separate jumpers in the previous case.

Possible Methods of Translator Cost Reduction

Let us consider again the translators of Figs. 6 and 7, which are modern types for local central offices and used on a sufficiently large scale so that the costs are important, and let us examine where there are possibilities of cost reductions.

Now these translators are designed for use in buildings with as many as four central office units, that is, 40,000 directory numbers and somewhat less equipment location numbers. Yet each translator can handle only 1000 input codes, so if both of these types of translation are involved, 40 translators of one type and somewhat less of the other will be required. Two things may immediately be considered as possibilities for reducing costs:

(1) Since the two types of translators effect translations between the same sets of equipment numbers and directory numbers but in reverse directions, it might appear that savings could be made by providing a single type of translator for both functions and arranged for 2-way operation without requiring duplication of the equipment.

(2) Since a considerable amount of equipment is involved in the large number of identical selection devices for coding elements in each translator and for connecting devices in the equipment selecting translators, savings might be made by reducing the number of translators required by increasing the speed of operation.

Electronic Cross-Reference System (2-Way Translator)

The writer, as a result of considering the foregoing possibilities a number of years ago, proposed a 2-way translator intended to effect savings over existing schemes of using two different types of translators operating in reverse directions, as in the #5 Crossbar case discussed above. As it was

[5] It is interesting to note that the coding schemes of Fig. 6 and 7 were both proposed by Mr. T. L. Dimond of the Bell Telephone Laboratories. The arrangement of Fig. 7 is often referred to as the "Dimond ring" translator. This pun is one of the rare exceptions to dullness in switching nomenclature.

For an earlier version of the ring type translator see *U.S. Patent* #2,265,884 issued to Mr. F. A. Korn, of the Bell Telephone Laboratories. Note that this patent applies to an *identifier*.

desired to reduce the number of translators required to the ultimate of one, the great speed needed in order to obtain the required capacity indicated the need for full-electronic methods. Because, figuratively, the equipment could refer to tbe translation system in terms of one number and obtain the associated number as an answer, in either direction, much as in a cross reference card file, the system was called an electronic cross-reference system. It is promising, but not yet practical.

In this scheme the general concepts of other translators were not avoided but were applied in a different way. For instance the idea of having the input code select a changeable coding element was not avoided. However, the selecting element itself was eliminated, making possible important savings. The select function was combined with the coding function. Each coding element acts as its own selector under control of the input code, say code A, and then supplies the wanted output code, say code B. The operation may be reversed by supplying code B as an input, which results in auto-selection of the same coding element, but this time code A is supplied as an output.

The general arrangement is shown in Fig. 8.

The auto-selection and coding element for each associated pair of codes is a special cold cathode tube of the multi-anode type, having ten point anodes and a common cathode. The anodes are symmetrically spaced around tbe cathode so that each anode to cathode gap has the same characteristics. Only eight anodes are used in this illustration.

Since there is one tube for each pair of associated numbers there will be a total of 10,000 tubes in this case. Four groups of ten numerical bus bars for the A numbers and the same for the B numbers, passing the entire tube field and cross-connectable to the anodes of the tubes, complete the translator proper. The extraneous equipment consists of "inquiry" and "answer" sections, each of which may automatically be connected to either the side A or side B bus bar system. The "run-down" element of the "inquiry" section contains electronic pulsing and sequence-control equipment for causing the auto-selection and coding operations.

The operation is very fast, the entire auto-selection and output code reading process involved in each translation being completed in less than a millisecond if all the connecting switching gear is electronic.

Assuming that an "A" number, say 1925, has been recorded in the register of an inquiry section, that this section has been connected to the bus bar system of the "A" side and the corresponding answer section bas been connected to B bus bar system, we are ready to make a translation. The electronic rundown equipment pulses into the bus bar system of the A

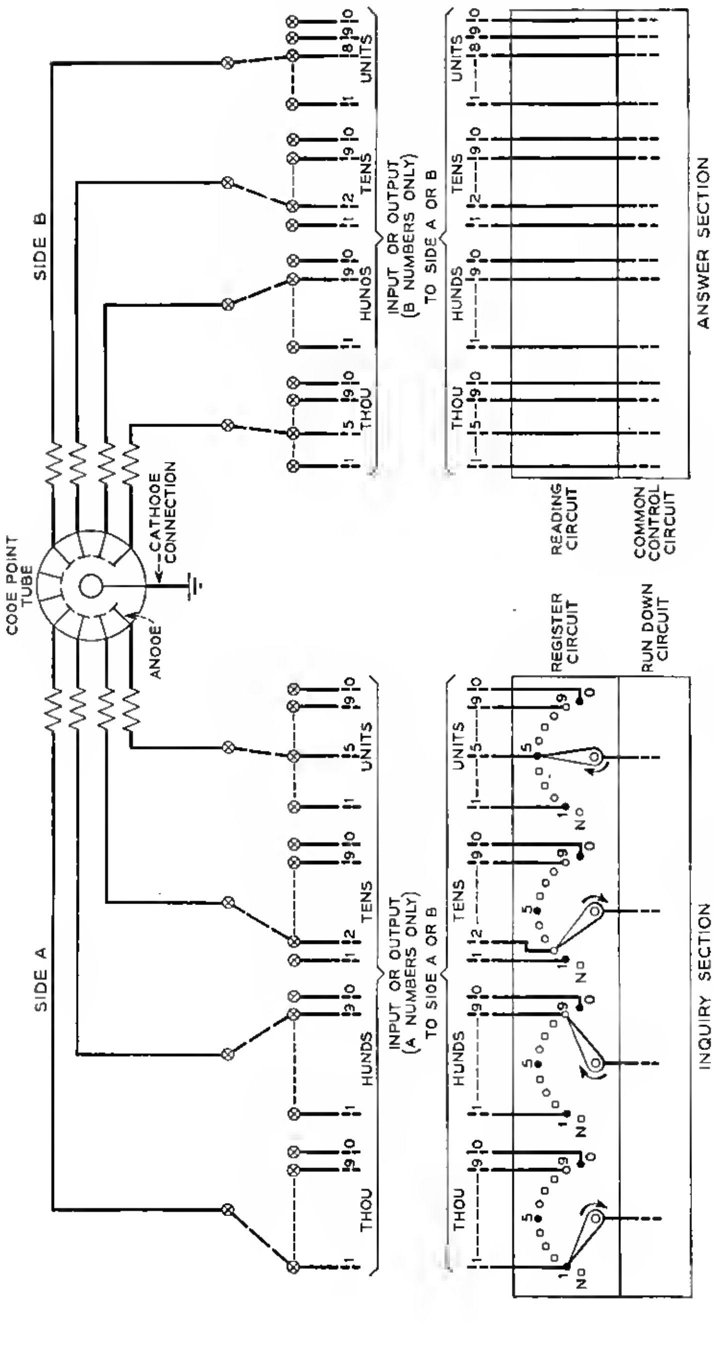

Fig. 8—Electronic cross-reference system (2-way translator).

side to cause the auto selection of the coding tube for (A) number 1925 as follows:

(1) Breakdown voltage is applied through the thousands register to the #1 bus in the thousands group of the A side. This causes breakdown, or firing, at the thousands anode of all tubes that have *one* as the thousands A digit. In a fully equipped system this would be $\frac{1}{10}$ of all the tubes, or 1000.

(2) "Sustain" or "hold" voltage (lower than breakdown voltage) is applied to the #9 hundreds bus, followed by removal of the voltage from the thousands bus. This causes all previously fired tubes which have #9 as the hundreds digit to be held ionized by the hundreds anode and the others dropped out, that is $\frac{9}{10}$ of the total tubes dropped out and $\frac{1}{10}$ or 100 held.

(3) This drop-out process is continued through the tens and units steps so that first ten and finally only one tube (number 1925) is held by the units anode. Auto-selection of the code tube required is now complete and it remains only to read the coding of the B side.

(4) Reading is accomplished by applying "hold" or "sustain" voltage to *all* the bus bars on the B side. This causes anodes connected to this bus system to fire by transfer in only the one tube which is ionized. Thus all B anodes in tube 1925 will be fired and the resultant currents in the associated bus bars (one in each of the 4 "B" groups) are marks which can be read in the electronic reading circuit to register the B output number 5928.

(5) The translator is dropped by removing all voltages, causing the selected tube to deionize, and the translator is ready for another job. All of this requires only the time of the various breakdown and transfer steps and intermediate deionizing times, totaling less than 100 microseconds.

The advantages of possible cost reduction are obvious especially for large scale applications. The disadvantages, in the form here shown, are:

(1) The possible hazards resulting from the fact that this is a single common unit with one-at-a-time operation.

(2) The tractability for general use needs to be improved as it is necessary to change all the 4 or 5 required jumpers on one side of a coding element in order to make a translation change.

(3) The special tubes need to be made in very large quantities in order to obtain the required low price.

Further work now being done may resolve all these difficulties.

This translator illustrates some of the variations the designer can consider

when dealing with a translation problem with a new approach, and also some which *must* be considered. These and other possible variations will be reviewed later.

Slide Bar Translator

This proposed device was the forerunner of one of the Bell System's most important projected translators and is worth examining for the new principles.[6]

In this case, as in the cross-reference system just described, one of the objectives was reduction in cost by eliminating the separate equipment for selecting the coding elements and combining the selecting equipment as far as possible with the coding equipment. A further purpose was to provide non-electrical coding elements with improved tractability for making changes.

The construction of this device is shown in Fig. 9. The coding elements consist of thin slide bars shown in Fig. 9(a), each notched in accordance with the input code on one end and the output code on the other. These are stacked as shown in Fig. 9(d). The selecting equipment is a combination of code bars, Fig. 9(b), which work in combination with the wide and narrow notches of the slide bars, so that when a combination of select code bars is operated according to an input code all slide bars except the one carrying the input code are restrained from sliding when the common operating magnet is actuated. The one slide bar slides to the right, this representing the selection of the coding element.

The reading code bars are now all operated and only the set corresponding to the output code of the displaced slide bar can operate fully. Contacts on the output code bars then mark the output code leads.

Because this device is slow relative to relay or electronic translators owing to its mechanical elements, it has limited traffic capacity and would have to be duplicated many times in each office. Its advantage, however, lies in the fact that, when changes in translation are to be made, new coding elements (slide bars) can be prepared in advance and the changes made simply by substituting the new bars for the old, without changing cross connections.

Card Translator

While the slide bar translator is sometimes spoken of as a "card translator" it is similar to but by no means the same as the card translator which the Bell System proposes to adopt for toll crossbar offices.

[6] See *U. S. Patent* #2,361,246 issued to Mr. George K. Stibitz.

This card translator will not be illustrated at this time, but the following general notes are in order:

The card translator is especially designed for toll application where a 3 to 6-digit decimal input must be translated to an output containing 30

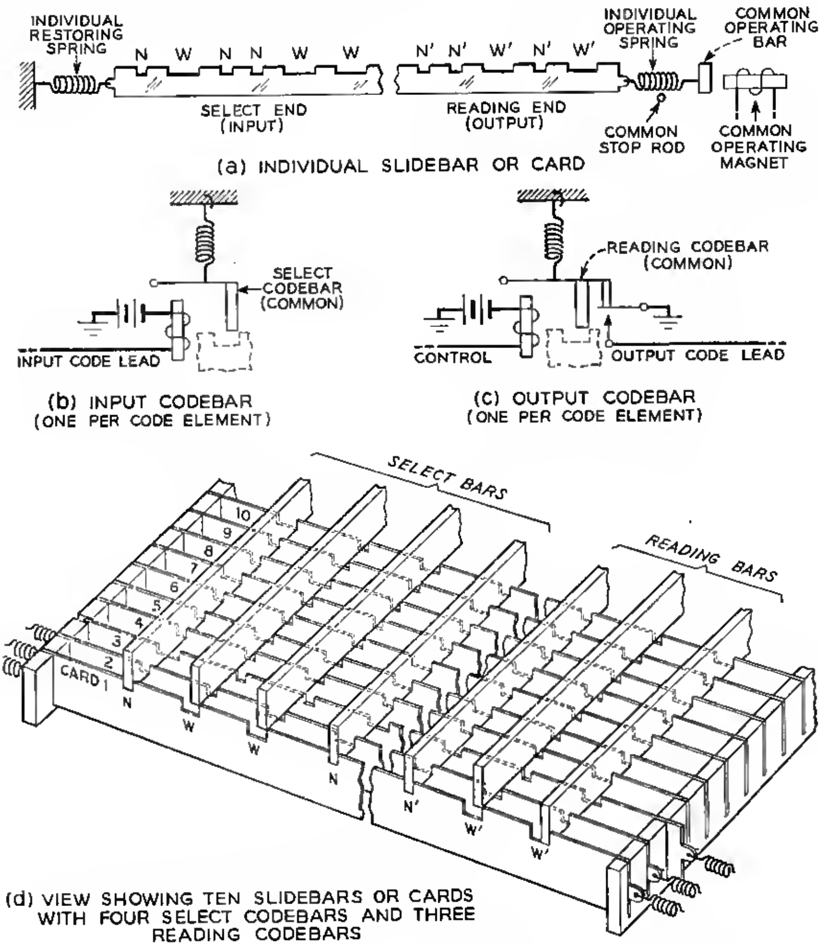

Fig. 9—Slide bar translator.

items of information with a very large number of possible combinations. The large number of possible outputs and the necessity of making changes quickly and frequently make the previously illustrated translators impracticable. For such application the card translator is well suited. The

coding elements consist of steel cards, notched at the lower edge according to the input code. The output code is carried on the card in the form of small and large holes.

The coding elements (cards) are selected, as in the slide bar translator, by selecting code bars that will drop the required card. Reading is done by photo cells (actually photo-transistors) which detect the presence or absence of light through the tunnels formed by the holes in the stacked cards.

Pre-translator for No. 5 Crossbar System

This all-relay translator is used for obtaining one of three possible sets of switching instructions at a time when it is impractical to consult the more complete office code translator associated with the marker in this system.

Provision is made for 576 possible input codes on a 3-place decimal basis each translatable to one of only three possible output codes each consisting of a mark on one of three output leads.

Because of these restricted capabilities it will not be illustrated here,[7] but its general principles are worth noting because it is an example of how close tailoring to the requirements can effect economy. This translator is one of the few examples of changeable translators which do not follow the general principle used in the previously described translators of this type. That principle, it will be recalled, is that each input code causes the selection of an individual coding element which determines the output code and changes are made by causing the selection of different coding elements or by changing the output of the coding elements.

In this pre-translator the input codes are teamed in groups of three, each of the group causing the selection of the same code point terminal. Hence only one third as many code point terminals are required as there are inputs. Each of these code point terminals is cross connected to one of 27 terminals, each of which represents a different permutation of each of the three possible outputs. At this terminal three possible answers are represented, and three relays beyond this point select the correct answer, depending on whether or not the input code is the first, second or third of the group of three.

Changes for any input code are made by changing the jumper affecting this code and its two associated codes to a new terminal representing the new permutation.

This arrangement reduces the required number of relay contacts, cross connections and cross-connecting terminals as compared to the number required by more conventional all-relay translators. It would become im-

[7] For a full description, see Pre-translation in No. 5 Crossbar, R. C. Avery, *Bell Laboratories Record*, April 1950.

practical if only a few more output codes were required because of the great increase in the number of permutations.

General Thoughts on Translators

Broad Considerations in Choosing Translation System

If a switching system designer were confronted with the problem of providing a large scale translator and he were given full latitude, there would be many factors he would have to consider and a wide variety of choices he could make in order to reach the most economical and useful design, even if he were uninventive and restricted to the combinations of the present art. Actually he would not have full latitude, for the translator design must always be coordinated with the design of other elements and often is subordinated or greatly limited by the importance of the more intricate or costly elements with which the translator must work. The best he can do is to arrange his design to help provide the most economical and serviceable system from an overall standpoint, and in this the translator design might not be ideal.

What are some of the more important factors that the designer can juggle and what choices can be made within the known possibilities?

Let us assume that the problem specifies, for some new type of common control office, large scale translation between equipment and directory numbers in both directions. Then the following decisions are certainly important:

(1) One-way or Two-way Operation?

This is determined by economic study if the available two-way translators are satisfactory.

(2) Should translators be provided for each circuit requiring their use or should they be provided for access to circuits in common?

This can be determined only be economic studies.

(3) If the translation system is to be common, should it be based on the use of a single full-capacity translator or numerous smaller translators involving more translator connecting devices?

This involves economic studies and questions of the speed or traffic capacity of the translator and the question of relative service hazards in the two arrangements.

(4) What type of translator shall be used?

This involves economics, speed, reliability, types of apparatus available and tractability for making changes.

Detailed Considerations

It has already been brought out that large scale changeable translators known to the present art follow the same basic concept and that there are, as a result, certain problems common to all of them.

Let us examine Fig. 10 to see how some elements can be varied to change costs. This figure shows four general arrangements for coding, all working into the same output code marking lead bus-bar system. In practice all of the coding elements of the same translator would be of the same form and a large number would appear before the bus system or sections of the bus system. In the general arrangement covered here the coding elements are arranged in numerical order each permanently connected to its associated output bus bars. Types of systems having no output bus-bar multiple, such as the Dimond ring, slide bar or card translators are not illustrated, but covered in the discussion.

Starting at the left with the input code leads, we have theoretically much choice as to the types of signaling (various combinational or sequential types) and the system of numeration making up the input code. In spite of this freedom most translators in use employ decimal inputs with signaling generally on a code marking lead basis or sometimes on a decimal pulsing basis. Where code marking lead signaling is used the marks are almost always simple off-on marks and, for decimal notation, each place is represented by a 1 out of 10, 2 out of 5 or combinations of 4 group. The practical choice is limited by the fact that it has usually been uneconomical to change the coding system of the translator input to other than that existing at the output end of the relay or switch devices making use of the translator, as this would require a change of language by intermediate translation.

If it were not for these limitations the number of input leads could be reduced by use of binary numeration for marking leads, or by signaling over a single pair of wires with any of the other well known methods of signaling. However, the reduction of leads could, in any case, effect only minor savings as the leads are short. The largest savings possible would be in the reduction of the amount of translator selecting equipment required.

The language of the translator input, of course, also affects the design of the coding element selector which could be any type of selecting equipment such as switches, relays, tubes or code-bar mechanisms or, in one proposal, self-selecting coding elements. Relay trees are frequently used and optimum designs for the common types of inputs are well established. For different types of inputs the design of such trees profits by mathematical analysis.

Now we come to the coding elements themselves.

Because of the large number of these, optimum design is important. In the illustrations and in most applications tbe output codes are formed by the coding devices placing marks on the output code marking leads. The output language could be different, of course, and possibly with economy in the translator itself, but the philosopby of using code marking leads in the output end is the same as that just mentioned for the input system.

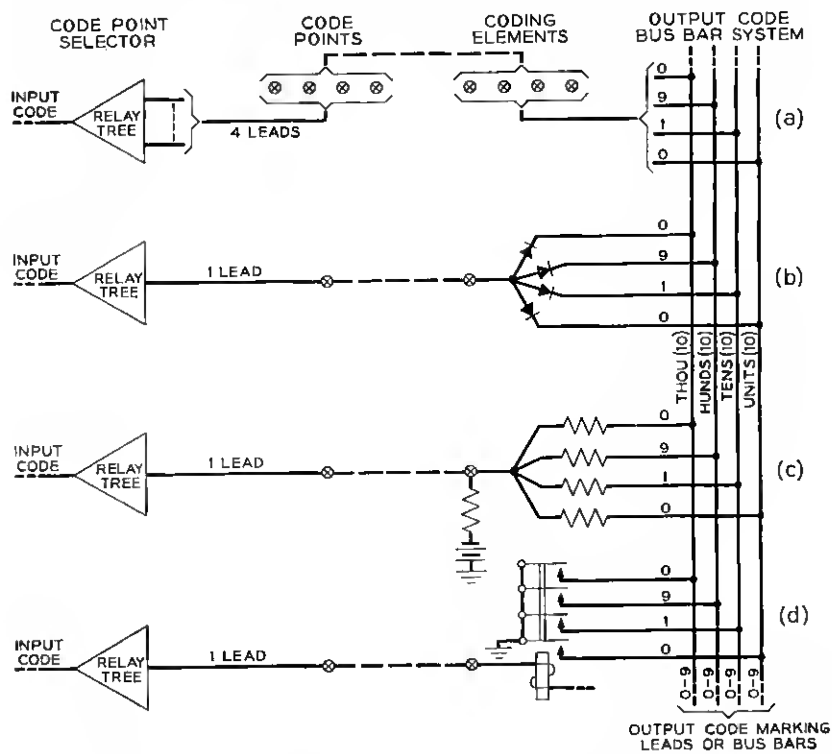

Fig. 10—Four general methods of output coding in changeable translators.

The coding methods shown require a multiple of all or part of the output code leads before the coding elements, that is, a bus system. It is the problem of the coding elements to mark the required buses in the various output groups without causing false marks on buses not involved by "back-up" through the connecting network or at least keeping the back-up below levels providing adequate discrimination between wanted and unwanted signals.

This back-up problem is solved in translators of tbe Dimond ring, slide

bar and card types by the fact that there is no bus-bar system, each output lead baving only one connection on the translator. Each electrical bus-bar is replaced respectively by a coil, a code bar channel or a light tunnel.

In systems using bus-bar output multiples the coding elements solve the coding and back-up problems in four general ways, as shown in Fig. 10, assuming that tbe output consists of four code groups:

(1) By having an individual lead tbrough the code-point selector and cross-connection field for each code group as shown in Fig. 10(a). Each lead is directly connected to the required bus. All are open in the selector except those involved in any individual translation, thus avoiding back-up. No apparatus other than the wiring is involved in the coding element. This saves apparatus, but the cost of the cross connections and the wiring apparatus in the coding element selector are higher than for the other cases because of the larger number of wires.

(2) Figure 10(b) shows a one-wire arrangement witb back-up prevented by a unilateral or non-linear element in each lead to the bus-bars.

(3) Figure 10(c) shows a one-wire arrangement which is connected to each of the four required output buses through a terminating and coding resistance network which reduces back-up through the unilateral effect provided.

(4) Figure 10(d), again one-wire through the selection and cross-connect field uses a relay to effect coding, back-up of course being prevented by the fact that the leads to all code buses are open at the relay contacts except those involved in a particular translation. Figure 8 operates on similar principles for avoiding back-up.

Schemes (b), (c) and (d) reduce the wiring and the selector costs as compared to (a) through the use of only one wire but tbis is done at the expense of the additional apparatus in the coding element.

Figure 6 shows a compromise between (a) and (c) of Fig. 10.

Different conditions for one-way translators may warrant a careful choice between one of the four general methods of coding shown in Fig. 10 and the methods involving no bus-bars mentioned above.

In the case of the arrangements of Fig. 10 some cost changes can be effected by juggling, in the design, with the coding elements and the bus-bar grouping.

For instance, if the number base of the output were changed from decimal to binary, the number of output bus-bars would be reduced from 40 to 14, but the increased number of places in each output would require 14 leads from each coding element instead of the present four. This complication of tbe coding elements would probably prove-out tbis change.

On the other hand, if the output number base were changed to centesimal the number of output bus-bars would be increased to 200 but the *reduction* in the number of places would *reduce* the number of output leads from each coding element to two. This might be of possible economic advantage. If it were not permissible to end up with a centesimal output, it would be necessary to provide a secondary translator to change the output from a centesimal to the decimal or other system required, and this would reduce the economy of the centesimal output.

What About New Concepts for Translators?

There are in the "proposed" state numerous interesting variations of the basic translator principle which has been outlined. These have as objectives lower system first costs and improved tractability for changes.

The general concept for changeable translators of the non-systematic type which has been repeatedly stated above appears in so many forms in practice and in inventions and suggestions ranging through varieties of mechanical, electromechanical, electro-optical and electronic types that one might wonder: (1) Is it not possible to design a large scale changeable translator with a different basic concept? (2) If it is possible, what might be gained?

We have noted, in the "pre-translator," a departure from the general concept of changeable translators, and there are others. However, they are all limited scale types applicable to special conditions.

A recently published article[8] indicates a new line of attack on the problem of obtaining a changeable translator with greater speed and reliability so that it could be used to carry a greater load than now customary. Not enough details are given to indicate whether the electronic arrangements outlined depart from the basic concept of existing translators, but, if they do not, they at least present interesting variations.

What could be gained by entirely new concepts for translators can not be answered in advance except in terms of what would be welcome. The present general designs give good performance and there is little need for improvement in this respect. What is always welcome is lower costs, particularly the cost of making changes.

Identifiers

What is Meant by "Identifier"

It was stated at the beginning of this paper that identifiers are relatively new in the switching art. This applies to identifiers which are sufficiently

[8] T. H. Flowers, "Introduction to Electronic Automatic Telephone Exchanges—Register—Translators," *Post Office Electrical Engineers' Journal*, January 1951.

limited in function or distinct as a switching unit to be so labeled. Un-named identifiers and identification processes have existed since the early days of the switching art. Only patent attorneys recognized these early arrangements and called them by their proper names.

Let us confine ourselves, for the moment, to the type of device generally named as an identifier. This is a device for indicating in code form the designation of a line, station, trunk, frame or other unit to which the device has a connection. The connection is generally electrical, but could conceivably be physical, optical or electro-magnetic.

Examples of Use

The term identifier first came into general prominence in connection with the introduction of "automatic ticketing" in the United States and Europe. These are systems used in connection with subscriber dialed toll calls for printing automatically a ticket carrying calling and called numbers and other details necessary to charge for the call. The identifier is the automatic device for determining the calling number, a function ordinarily performed in manual service by the operator asking for the number. With the identifier it is also possible, on those calls requiring the service of an operator, to display the calling number automatically so that the operator's request can be avoided.

Another example is found in Bell Crossbar Offices of the toll type in which it is necessary for certain equipment to determine the number of the frame on which a calling trunk is located. For this purpose, what is known as a "frame" identifier, is used.

Of course, no arrangement for fully automatic completion of long haul toll calls can be successful without an automatic system for making a record of the details necessary to charge for the calls, including automatic identification of the calling number. Identification processes will, therefore, become more and more important.

Typical Identifiers

General

Existing identifiers follow a number of basic concepts but many variations of these fundamental notions are possible. A few examples illustrating the different concepts with some of their variations will be given. The task is simplified because some of these concepts have a strong resemblance to translator principles which have already been discussed.

Calling Number Identifiers—Searching Type

Figure 11 shows an identifier used in the Bell System's first application of automatic ticketing[9] and with variations in similar applications elsewhere.

The principle here is that the identifier, through the outgoing trunk to which the calling line has been extended, applies a tone to the sleeve terminal of the calling line, utilizing the sleeve through all the switching stages. This tone finds its way through an equipment-to-directory number translating jumper to one terminal common for each 1000 numbers, one common for each 100 and one per number in each one hundred block. The numbers of the terminals with tones correspond to the various decimal digits of the calling numbers.

Relays connect tone detection equipment sequentially to the various thousands, hundreds, etc. terminals and each time the tone is found the corresponding digit is registered on relays in the identifier. These relays mark the output code leads.

The variations in other identifiers of the searching type consist of the use of switches or tubes instead of relays, searching for special d-c. voltages instead of tone, and in transmitting the digits of the identified number back to the source of the identifying signal by pulses over the sleeve instead of transmitting them to code marking output leads.

This type of identifier is obviously rather slow because of the sequence of operations and it is, therefore, necessary to provide a plurality of identifiers for each office. The different identifiers are prevented from interfering with each other by preference lock-out circuits, by discriminating signals such as different tones or by other special means.

All-Electronic Calling Number Identifier

This proposed identifier works much like a translator in that a coding element individual to each number is selected and this places marks on a decimal bus-bar output system. Referring to Fig. 12, it will be noted that there is a directory number field with a multi-anode tube of the type used in Fig. 8 for each number plus an RC filter to discriminate against surges. This identifier provides for party lines and for class of service indication requiring the two extra cross connections shown.

The operation consists in the application by the control unit through the trunk and the switch sleeves to the line equipment sleeve terminal of a 10-millisecond pulse of +135 volts. This finds its way through the normal

[9] O. A. Friend, "Automatic Ticketing of Telephone Calls," *Electrical Engineering*, Vol. 63, Transactions, pp. 81–88, March 1944.

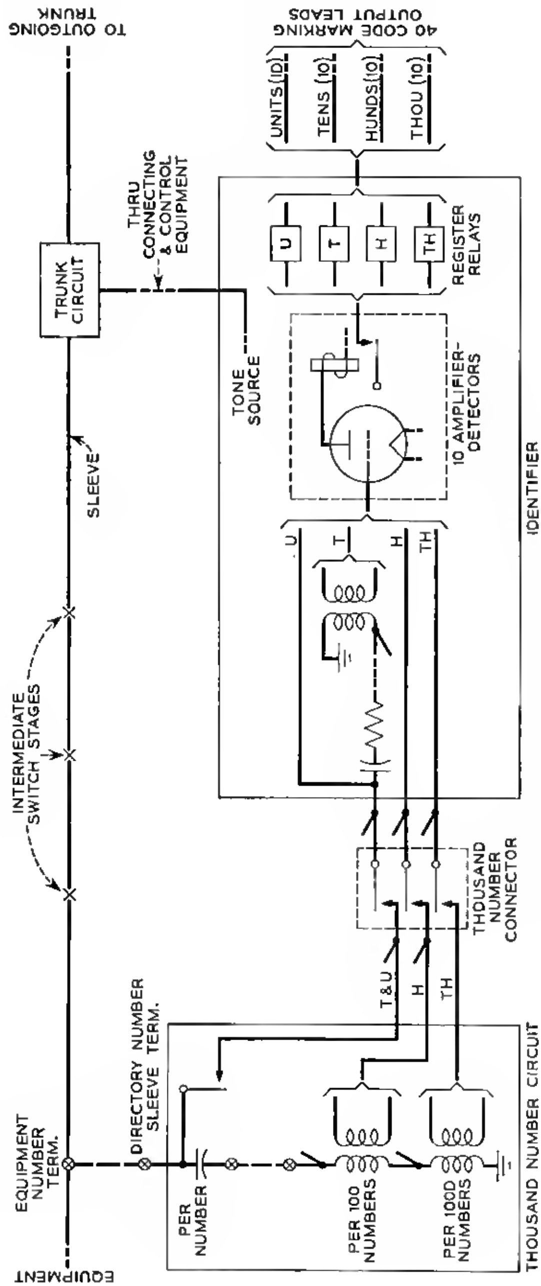

Fig. 11—Calling number identifier of tone-searching type.

cross connections (acting as translators) to the sleeve terminals of all the directory numbers associated with the line and the start anodes of the corresponding directory number tubes, firing each of these tubes at the start anodes. Continuous hold voltage (+75) is also placed on one of the hold or "party" buses through the party station register (station identity previously determined).

When the operating pulse ends, the cessation of current through the start anodes causes all the operated tubes to de-ionize except the one for the

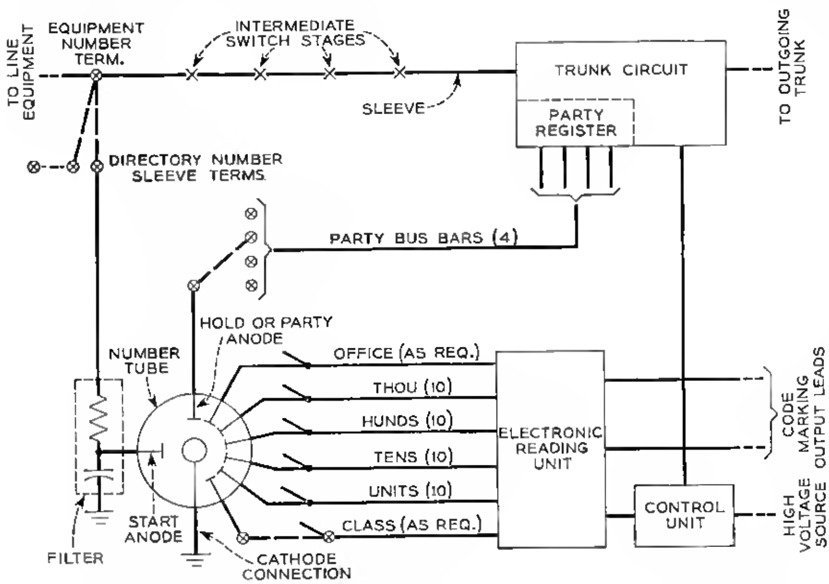

Fig. 12—All-electronic calling number identifier with multianode tubes as coding elements.

wanted number which is held, through ionization transfer, by the party anode. The tube for the wanted number has now been selected and the output code is read by the reading circuit by applying hold voltage to each bus of the system, causing all the coding anodes in the wanted number tube, and in only that one to conduct. Current then flows in one bus in each group, including the class of service group, which indicates the digits for the number and class of service, which are registered electroncially in the read unit. The register reading is transferred to the output code marking lead system.

This operation requires less than 30 milliseconds, which means that a

single identifier has capacity to handle up to 50,000 numbers on a one-at-a-time basis.

This identifier has not been developed beyond the laboratory stage.[10]

Passive Element Identifier

Figure 13(a) shows a scheme for the identification of calling numbers by the use of an identifier containing passive element output coding devices consisting of condensers and resistors. The general operation is simple. A tone is applied, again through the trunk and the switching sleeve and the normal equipment to directory number cross connection to the directory number terminal. This tone passes through the termination and coding elements to the bus-bar system, the code for the associated number being formed by a tone mark on one bus in each decimal output group. Common detectors and discriminators detect these tones and register the identified number on an associated electronic register. From the register it is transferred to the output system by suitable marks on the code marking leads.

This identifier operates in about the same time as that of Fig. 12, that is, less than 30 milliseconds, and is therefore also capable of serving 50,000 lines without duplicating the translator equipment. This device is not in use but is testing satisfactorily in the laboratory. So far it seems the most economical of all the various types suitable for calling number identification.

Identifiers Arranged for Transmitting Identity Code to Input

Figure 13, (b) and 13(c), shows two variations of identifiers operating on the basis that the identification code formed by the coding elements is not transmitted to a common output but back to the input end.

Figure 13(b), used for calling number identification, uses non-linear coding elements which are non-conductive normally. When a start voltage is applied to one of the coding elements from a trunk or a control element through the switching stages on one of the switching conductors, the coding element becomes conductive and connects the input end to the coding bus-bar system which causes the identifying code to be sent back to the inquiring source. The identifying codes in this case are combinations of frequencies or multiplex pulses. This device is in commercial operation.

Figure 13(c) shows a similar arrangement used in the Bell System for identifying frame numbers in a crossbar system.[11]

[10] There is no published material on this identifier. A patent has been allowed Mr. R. P. Murphy of the B. T. L. An earlier version of this identifier is described in *U. S. Patent* 2,319,424 issued to Mr. M. E. Maloney of the B. T. L.

[11] O. Myers, "Multifrequency Frame Identification in Crossbar Toll," *Bell Laboratories Record*, September 1944.

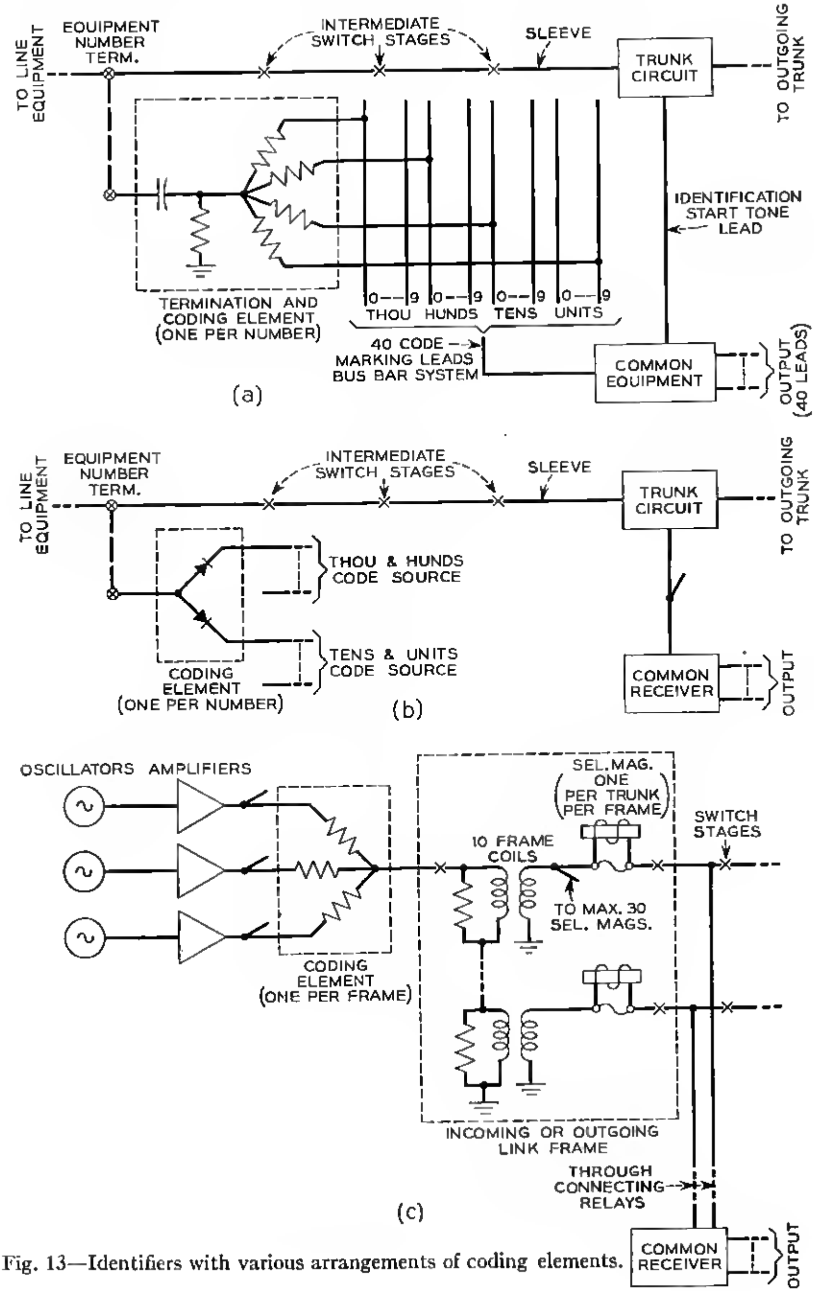

Fig. 13—Identifiers with various arrangements of coding elements.

Here all the trunks in the same frame have one lead permanently connected to a coding element which produces a 3-frequency code. This lead is connected to common detection equipment when the frame identification is wanted and this registers the frequencies and converts them to an output on a code marking lead system.

Identification by Reading Positions of Normal Selectors

There are numerous patents and a few commercial systems involving identification of calling subscribers, calling trunks, selected trunks, selected senders or registers, etc., in which the identification process consists in reading the position of the line finder, switch or relay unit which has been operated to select the line, trunk or other unit involved.

One of the oldest patents on calling number identification involves this principle.[12] The number of the switch group plus the number of the switch setting may in certain cases correspond directly to the wanted code. In other cases this indication must be translated, sometimes to a new arbitrary code and sometimes to obtain a code in a different numeration or signaling system.

Two methods of reading the switch positions are used: (1) counting of the steps or checking and registering other action taken by the switch *during* the time the involved line or other circuit is being selected, and (2) checking and registering the switch position *after* selection.

One of the interesting applications of this method for calling number identification where the line finder group and position numbers indicate the calling number is illustrated in the article covered by footnote No. 2.[13]

Comments on Identifiers

The identifiers we have discussed are divided into the following general types:

(1) Searching types
(2) Coding element types
  Type A—with transmission to common output
  Type B—With transmission to source over input lead
(3) Switch position reading types

The first two types depend on the use of a considerable amount of equipment comprising the identifier and a large number of leads, and the problem of economy is generally solved by using one of the regular conductors of each connection (usually the sleeve) as part of the identification circuit.

[12] Mr. W. W. Carpenter et al, U. S. Pat. 2,112,951.
[13] R. F. Stehlik, "La Louviere Automatic Network of the Belgian Telephone System," *The Automatic Electric Company Technical Journal*, January 1951.

This procedure, in practice, requires that the identification equipment be arranged to discriminate against the surges directly introduced on these leads by other equipment connected to them and against crosstalk resulting from capacitive or magnetic coupling to other leads. This is done in part by adjustment of impedances and by discriminators either at the coding elements or in the common circuits. The problem of feedback has been discussed under Section II. There is no special technical difficulty in this but the economics is important.

The tbird general type has no special problems due to large numbers of wires or coding elements or feedback or crosstalk. The economic considerations involve the additional equipment in numerous other switching elements to read the switch positions and the fact that, if the switch position does not directly give the wanted number in the desired code form, resort must be made to additional translation.

Future possibilities lie in new methods avoiding these various problems economically, probably metbods with entirely new basic concepts.

Conclusion

General Remarks

Tbe similarity of the problem of identification to that of translation is obvious. In identification the general problem is to construct an output code for information on an item to which the identifier has a connection. In translation the problem is to construct an output code for information on an item for which the translator has a previously registered code to use as input information.

Now, if we stretch the point, we could very well say tbat the identifier, because of its connection to the object being identified, also has an input code when a signal to start identification is applied to this connection, the input code simply being a mark on a one-out-of-X basis.

What is probably of more importance than the similarity of identifiers and translators is the frequent occurrence in switching networks of elements that functionally or operationally or both are essentially translators or identifiers although they are not so named.

The ordinary line relay, responding to the subscriber wben he starts a call, can be considered as a coding element in a translator in some simple dial systems, as it translates an input code consisting of a mark on one out of 100 leads to marks in a two-place decimal system used to direct the line finder to the line. In the case of the No. 5 crossbar system, the line relays and their associated group equipments, although not so named, can certainly be considered as a identification system as the end result of their operation is the registration of the calling equipment number in a common

unit and in some patent literature the term "calling line identifier" is actually used. In practice this number is later used as an input to a translator (Fig. 7) to obtain the calling directory number. Any relay not serving merely as a means to renew or register a signal acts as the coding element of a translator or identifier.

Finally it looks to the writer as if any of the units made up of numerous relays, or other devices, as used in common control systems, act like translators with a vast number of possible input and output combinations with the action resulting from the output codes often fed back as part of a new input code.

There might then be considerable possibility that any fundamental improvement in general switching network theory or in the theory of translators and identifiers would be of mutual advantage.

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